(12) UK Patent Application (19) GB (11) 2 164 871 A

(43) Application published 3 Apr 1986

(21) Application No 8424374

(22) Date of filing 27 Sep 1984

(51) INT CL⁴
B01D 13/04

(52) Domestic classification
B1X 6C 6F1 6G1 6J7 6L3
U1S 1250 3031 B1X

(56) Documents cited
GB 1546529 GB 1457476 GB 0489654
GB 1485537 GB 1256732
GB 1464011 GB 1256731

(58) Field of search
B1X

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(54) Membrane cartridge/element

(57) The cartridge/element is for separating a desired substance from a crude feed solution (e.g. for desalination). Semipermeable membranes (1) are rolled into a cylindrical structure together with a spacer layer (2) and a support layer (4) to define two separate spiral spaces between the membranes, one for receiving the crude feed and the other for receiving the permeate.

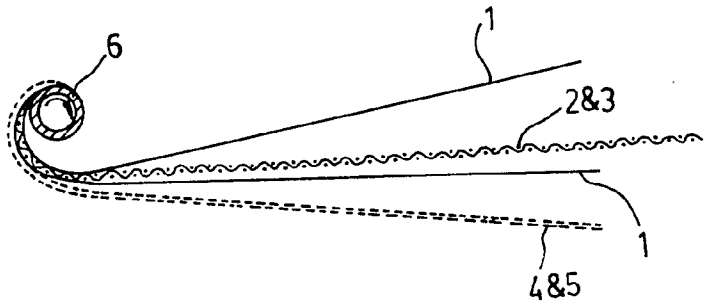

FIG.1

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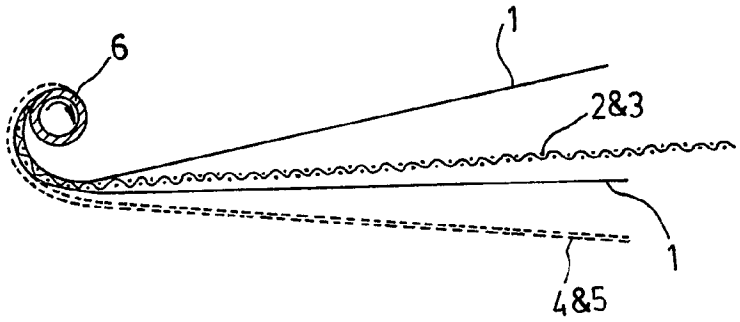


FIG.1

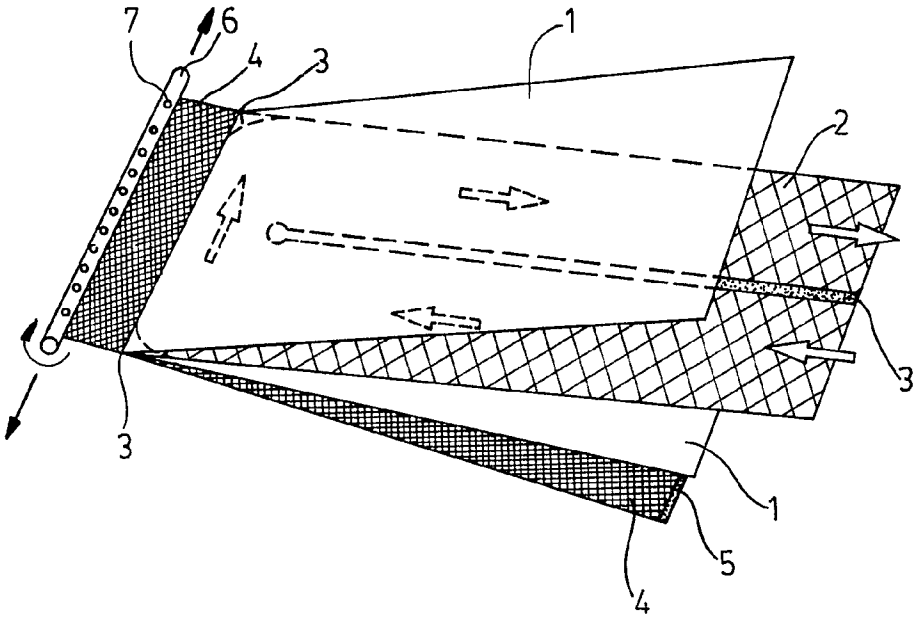


FIG.2

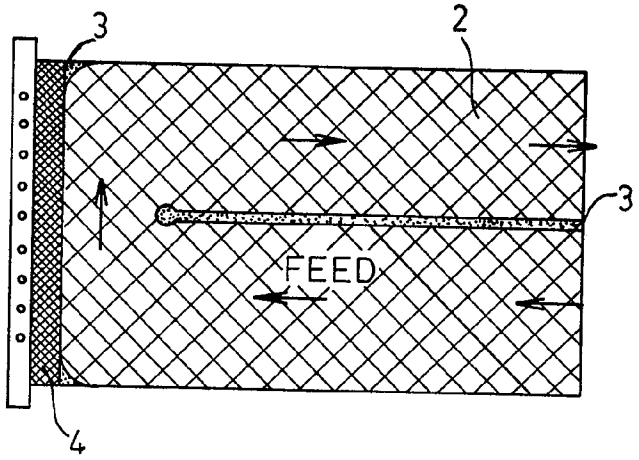


FIG.3A

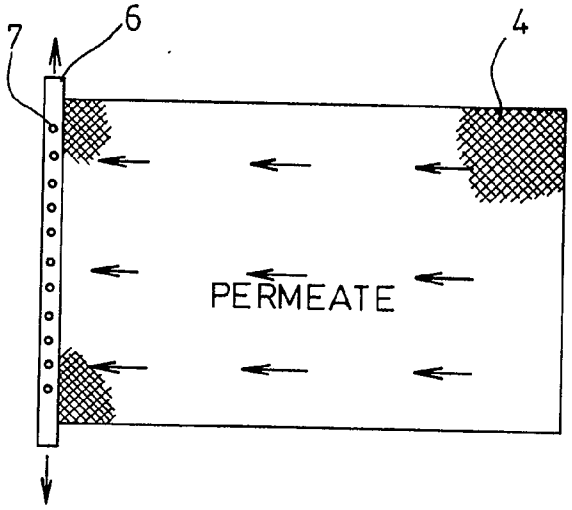


FIG.3B

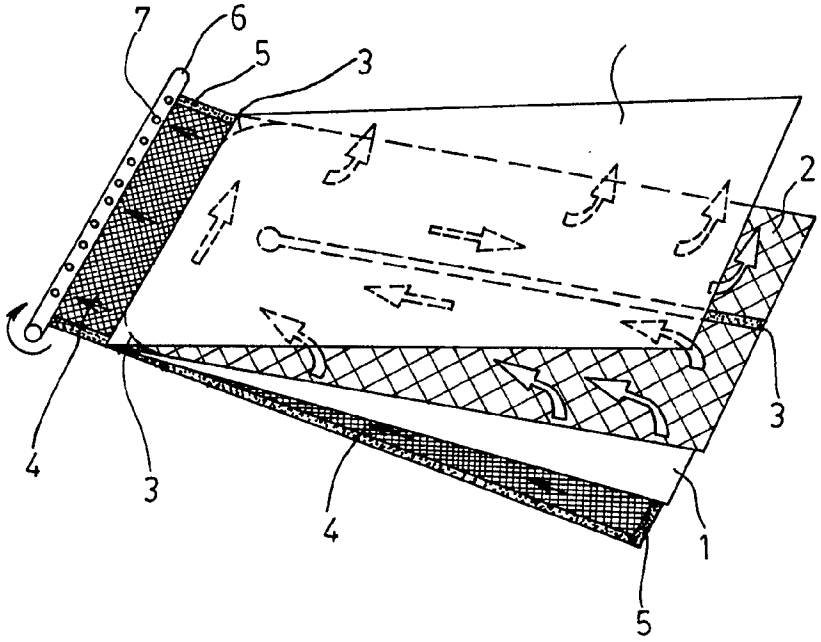


FIG.4

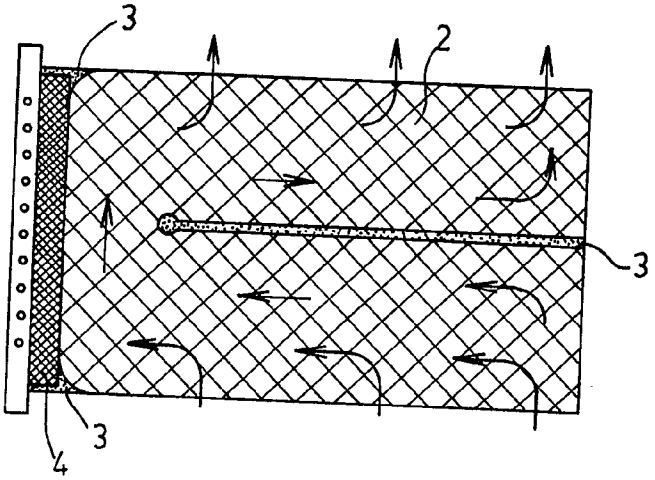


FIG.5A

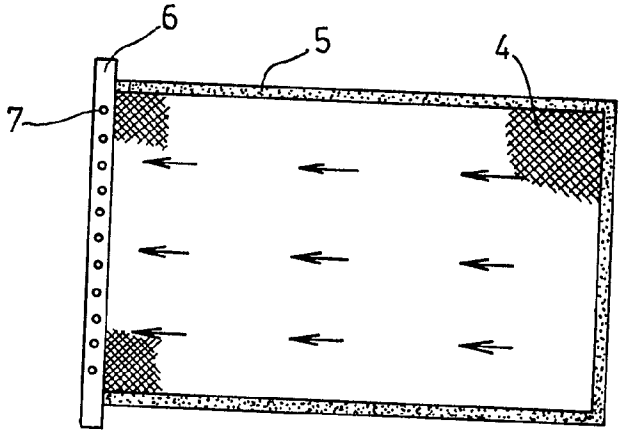


FIG.5B

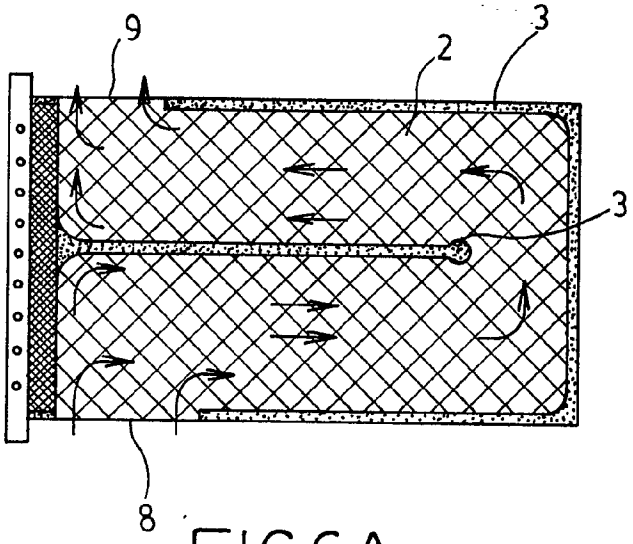


FIG.6A

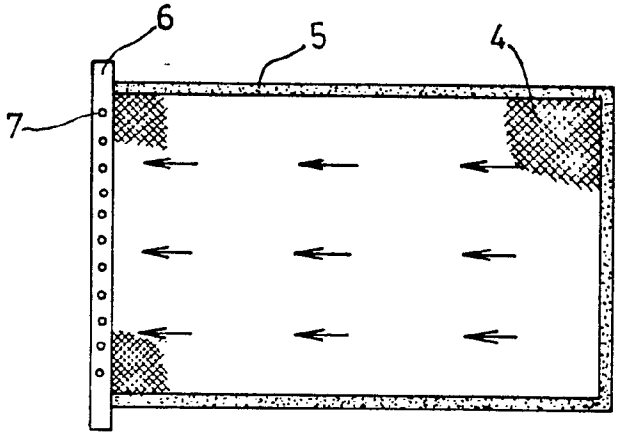
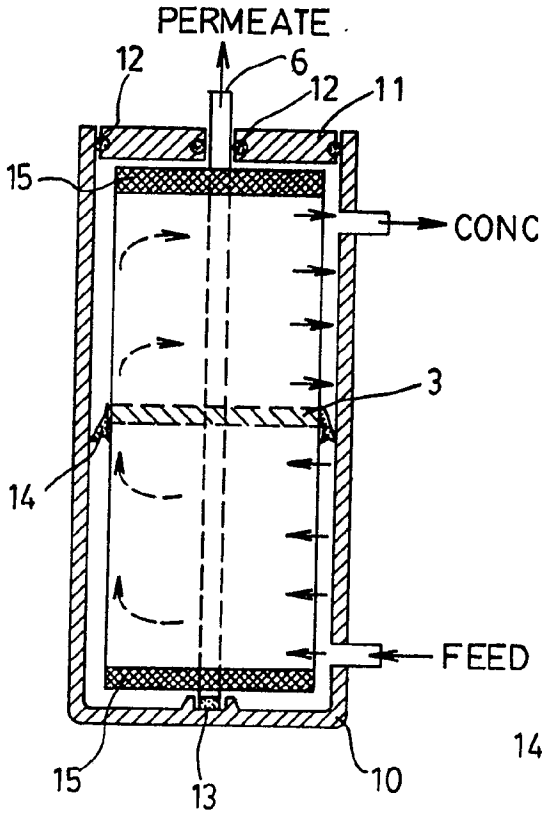


FIG.6B


PERMEATE
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FEED
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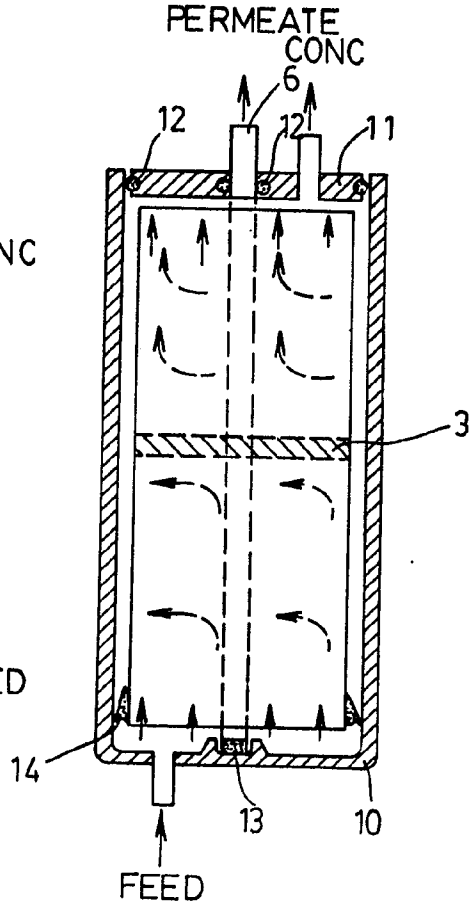
FIG.7A


PERMEATE
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FEED

FIG.7B

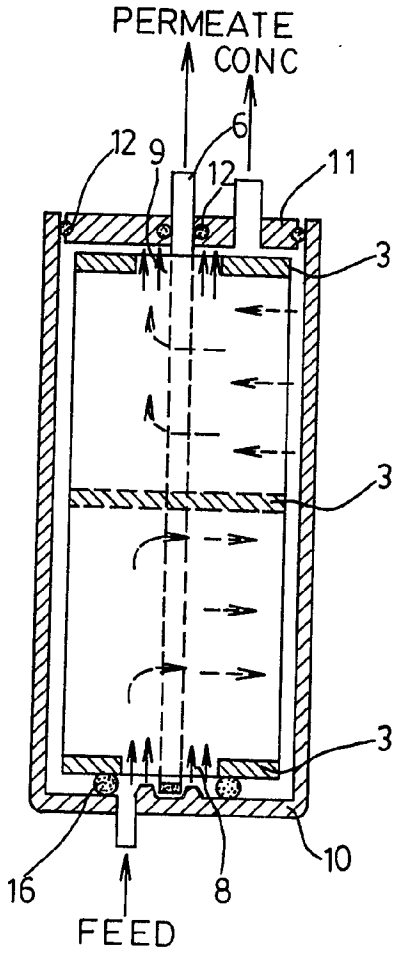


FIG.7C

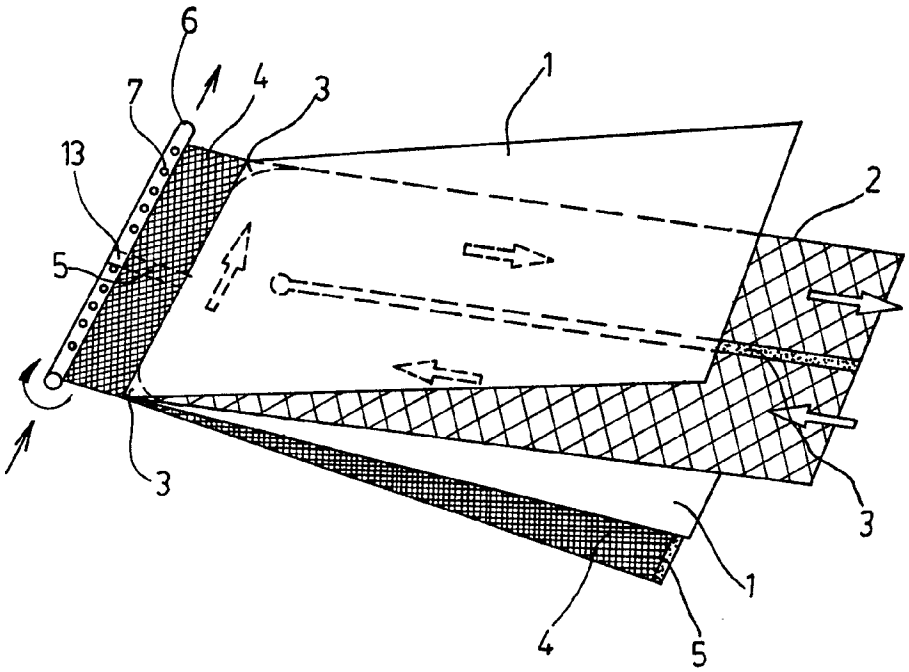


FIG8

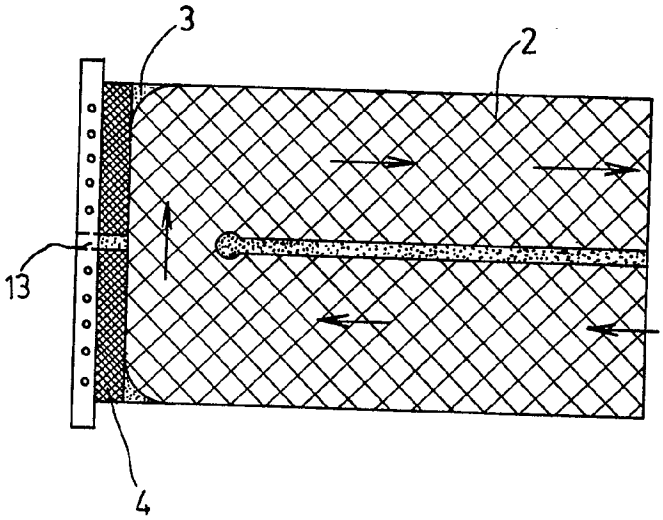


FIG.9A

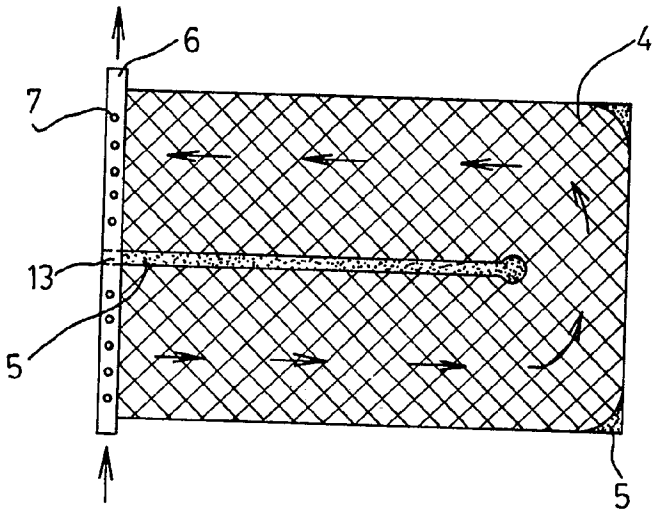
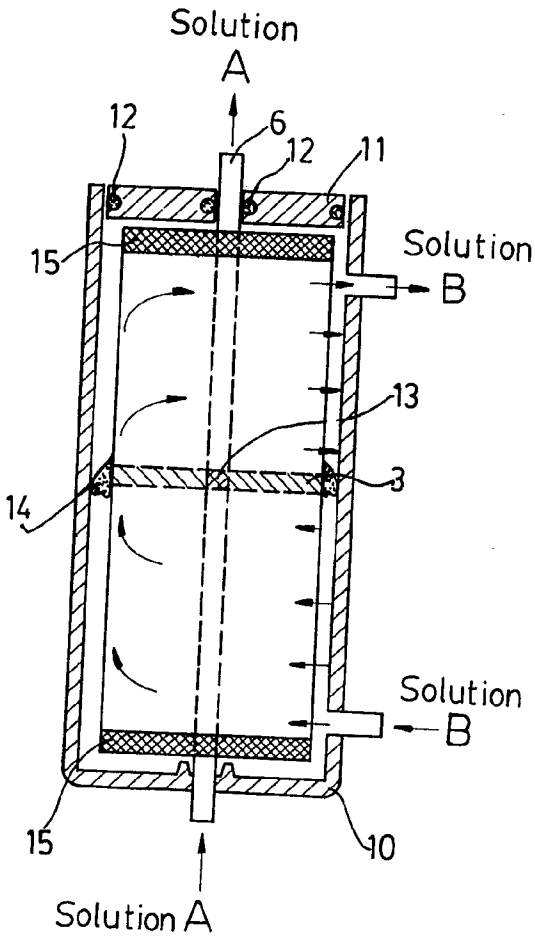


FIG.9B


Solution
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Solution
B
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Solution
B
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10
Solution A

FIG.10

SPECIFICATION

Membrane cartridge/element

This invention relates to a membrane cartridge/element for water desalination, water purification and solvent/solute separations. A prior art of this type of process is known as reverse osmosis and/or ultrafiltration. Reverse osmosis is a process applying a pressure greater than the osmotic pressure of a solution to force water or solvent to pass through a semi-permeable membrane and to reject the solute or salt dissolved therein. It was discovered by Dr. C.E. Reid in 1957 and was greatly improved in permeate flux by Dr. S. Loeb in 1963 to allow this process to be rationalized. Ultrafiltration is also a pressure driven membrane process similar to the former with the exception that the membrane has larger pore size and can only reject large molecular solutes. Currently, reverse osmosis and ultrafiltration have been widly applied in water purification, water pollution control and in industrial separations. In recent years, the water quality in many parts of this world are deteriorated due to the contaimination by pollutants, chemicals etc. The need of membrane separation processes of low energy consumption for water purification is rapidly increasing. The reverse osmosis and/or ultrafiltration membrane cartridge of this invention is particularly suitable for small scale and/or household water-purifying systems.

In order to increase the membrane surface area per unit volume, hollow fiber and spiral wound configulations are by far the most popular. Furthermore, in small scale and/or household applications, the feed pretreatment is usually not so good as large scale system. Fouling and scaling are often observed in such system wherever proper feed pretreatment is lacking. Spiral wound membrane cartridge/element is usually considered in those places where the feed pretreatment is inadequate. In the case of the prior art of spiral wound membrane cartridge/element of this type, the feed fluid flows parallel to the permeate tube and the water or solvent permeates through the membranes into permeate channel and flows toward and into permeate tube. However, this type of spiral wound cartridge/element for small scale and/or household applications still has many disadvantages. Firstly, the feed flow path is unsatisfactorily short, thus requiring a large feed capacity to maintain a feed flow velocity. Secondly, the glud line width is difficult to control, hence losing considerable effective membrane area. Thirdly, it requires a substantial amount of labor for the glue lines and is not adapted to mass production.

The object of this invention is to provide a membrane cartridge/element which allows a much higher feed velocity with lower required feed flow rate to reduce the polarization effect and/or fouling and scaling, which makes possible a minimum width of glue sealing line to increase effective membrane surface area, and which enables the cartridge/element to be produced with less labor. A further object of this invention is to increase the reliability of performance and the potential of mass production.

According to this invention, a sheet with at least two stacking layers of semi-permeable membranes is rolled into a scroll to form a cylindrical body. The two membranes are separated from each other by a small clearance, thus defining two separate compartments, separated from each other by the membranes, respective serving as the path for the crude feed and for the permeate.

The feed channel or compartment is spirally wound and may consist of a sinuous path which greatly lengthens the effective flow path in a definite volume, thus increasing the flow velocity of the feed and reducing the polarization effect. The permeate channel is spirally wound and may be sealed by potting with thermal set resins to reduce the required labor in fabrication and to ensure a perfect sealing. The feed channel and permeate channel are separated by means of membranes, monofilament screen spacers, membrane support screen, gasket seal and adhesives and/or thermal set potting resins. The membrane cartridge/element as described in this invention has multiple passes of feed channel. Therefore, high feed velocity with less volume of feed solution can be achieved and reduces the tendency of membrane fouling/scaling and prolongs the life of the membrane. The feed flows into and out of the feed channel from the side of cartridge/element. Thus, the sealing for the permeate can be made by potting both ends of the cartridge using thermal set resins. By using potting, the width of glue line can be minimized and the effective membrane area can be increased. Also, by using potting, the required labor in fabrication is decreased, and the reliability and the production rate are elevated.

Furthermore, the lengthened path of feed channel can can also be created by using gasket seal of feed channel in conjunction with the glue seal of the permeate channel. The crude feed solution is introduced into the feed channel from one end of the membrane cartridge/element and leaves the feed channel from the other end of the cartridge. In the case of small scale and/or household systems, a single membrane cartridge/element is usually required. It is difficult to maintain high feed flow velocity with low feed flow volume in the conventional means. Therefore, a considerable amount of energy and feed water are wasted to maintain a sufficiently high feed flow velocity. However, in the case of the membrane cartridge/element as described in

this invention, the high feed flow velocity with low feed flow volume can be achieved by means of the lengthened feed channel.

This invention can be better understood when read in connection with the accompanying drawing.

Figure 1 is a side view showing that two semi-permeable membranes, a spacer layer and a permeate support layer are being rolled around a tube;

Figure 2 is a perspective view of the membrane cartridge resulting from Fig. 1 revealing the seal which defines a U-shaped route for the crude feed;

Figure 3A and *3B* are the plan views of the feed side of the spacer layer and the permeate side of the support layer, respectively showing the flowing direction of the feed and the permeate;

Figure 4 is a perspective view of a variant of Fig. 2, with the edges of the permeate support layer mostly sealed;

Figures 5A and *5B* are similar to Figs. 3A and 3B, respective showing the flowing direction of the feed and the permeate in the membrane cartridge in Fig. 4.

Figures 6A and *6B* are similar to Figs. 3A and 3B, showing the flowing direction of the feed and permeate in a further variant of the membrane cartridge.

Figures 7A, 7B and *7C* are the longitudinal sectional views of the separation apparatus respectively with the membrane cartridge/element in Figs. 3A, 3B, Figs. 5A, 5B and Figs. 6A, 6B.

Figure 8 is the perspective view of still another modification of the membrane cartridge/element, in which the permeate support layer is also provided with sealing means to define a U-shaped path for the permeate;

Figures 9A and *9B* respectively show the flow direction of the crude feed and permeate in the membrane cartridge/element in Fig. 8;

Figure 10 is a longitudinal sectional view of a separation apparatus using the membrane cartridge/element in Fig. 8.

With reference to Fig. 1, to construct a structure with two spiral spaces separated by two semi-permeable membranes, a spacer layer (2) for the feed and a support layer (4) for the permeate. The spacer layer (2) and support layer (4) serve to maintain the clearance between the two membrances (1). The feed channel gasket seal (3) and the permeate channel glue seal (5) serve to ensure the feed and permeate not to mix. The layers are rolled around a perforated permeate collection tube (6). The perspective construction view of membrance cartridge/element with side feeding lengthened feed channel is shown in Fig. 2. The feed channel/spacer (2) is a monofilament screen material, such as: Vexar R, a polypropylene screen produced by DuPont and the feed channel gasket seal (3) is pre-formed rubber gasket material such as a silicone rubber, Dow Corning's Sylgard 170 (Viscocity modified with carbolic M–5). The feed channel gasket seal (3) is pre-formed onto feed channel/spacer (2) as shown in Fig. 2. The permeate channel/support (4) in a fine monofilament screen film, such as tricot fabric which is attached to perforated permeate collection tube (6), on which approx. 1/16" or less small holes (7) are drilled to allow the permeate to flow through. On the top of permeate channel, membranes (1) and feed channel (2), in which feed channel gaskets (3) are pre-formed by pregnanted the monofilament screen with silicone type rubber, are properly positioned and the components are rolled into cartridge according to Fig. 2's illustration. The permeate glue seal (5) may be applied during the rolling operation. When the cartridge/element is rolled to a proper diameter under proper pressure or tension, the center and both ends of the cartridge are preferably wrapped with water proof plastic tap and a brine seal (14) is usually installed at a position near the center feed channel gasket seal to force the feed to flow along desired flow path. Both sides of permeate channel (4) are sealed by potting both ends of cartridge including permeate and feed channels by using thermoset resin, such as polyester urethane. H. B. Fuller UR–2183 or UR–2139 or Epoxy or other resins. Therefore, the feed and permeate are completely isolated by membranes (1) permeate glue seal (5) and the potting resin (15) to form two separate streams i.e. feed and permeate streams. The feed flows in the feed flow direction shown in Fig. 3a and the permeate permeates from the feed channel through either of the two membranes (1) and flows in permeate flow direction as shown in Fig. 3b. Fig. 4 further illustrates another way to lengthen the flow path and therefore increase the feed flow velocity by using U-shaped flow path, with the feed entering the cartridge from one end and leaves it from the other end. A feed channel/spacer (2) with preformed feed channel gasket seal (3) membranes (1) and perforated permeate tube (6) where a permeate channel (4) a fine monofilament screen, is attached are reeled to form a membrane cartridge/element. During the rolling operation an adhesive such as polyester urethane, H.B. Fuller UR–2183 or UR–2139 etc. is applied along glue line 5. After the cartridge is relled to a proper diameter under proper pressure or tension, the outside of the cartridge/element may be wrapped with water-proof tape and/or coated with resin and the brine seal (14) may be installed at either end of cartridge or at the center of the cartridge to guide the feed fluid to flow into the feed channel along desired flow path. Therefore, the feed flows in the feed flow direction as shown in Fig. 5a and the permeate under applied pressure permeates through the membranes (1) and flows into the permeate chan-

nel in the permeate flow direction as shown in Fig. 5b and flows through the small holes (7) and are collected in permeate tube (6). It is noteworthy that the feed flow path is not restricted to the two-turn U-shaped path as shown in the embodiments. If desired, more feed-channel gasket seal can be used to define a three-turn S-shaped path, a four-turn W-shaped path, or other more complicated labyrinth-like path, so long as the path can travel throughout the whole area of the membrane.

Furthermore, the feed channel gasket seal may be re-arranged as shown in Fig. 6a. The feed fluid flows through gasket inlet (8) and enters the feed channel (2) along the desired flow path, guided by feed gasket seal (3) and exits through gasket outlet (9). The feed flow and permeate flow directions are illustrated in Fig. 6a and 6b. Needless to say, the feed flow passes is not restricted to the two-turn U-shaped path.

Fig. 7a illustrates the sectional view of a typical separation apparatus with membrane cartridge/element of this invention which comprises pressure vessel (10), cover plate (11), O-ring (12) permeate flow plug (13), brine seal (14) and end pottings (15). The feed is introduced into and out of the side of the cartridge/element and the permeate is collected through the perforated permeate tube (6). Fig. 7b illustrated the sectional view of another type of membrane cartridge/element of this invention as installed in the separation apparatus. The fluid feed enters into one end of the cartridge and exits from other end of the cartridge. Fig. 7c illustrates the sectional view of another type of membrane cartridge/element of this invention as installed in separation apparatus to provide a different feed flow pattern. The membrane apparatus consists of the components similar to the description as shown in Fig. 7a and/or 7b with the exception of brine seal O-ring (16) and the feed flow pattern.

The design of the lengthened path of the feed flow path, if desired, can also be applied to the permeate flow channel, as illustrated in the Figs. 8, 9A, 9B and 10.

The device according to this invention can achieve a far greater effectiveness for mass transfer than what the conventional type of membrane separation apparatus can provide Its another conspicuous advantages resides in that it can be easily cleaned by reversing the flow. In other word, pressurized distilled water can be introduced from the outlet of the permeate channel to permeate through the membrane into the feed channel to remove the accumulated solute on the feed side of each membrane to carry them away and leave from the inlet of the feed channel, thus renewing the membrane.

Practically the membrane element according to this invention can be scaled up or scaled down, depending on its application. It can be of either built-in type in the pipe line, or of replaceable cartridge type. The former is suitable for large plant and the latter is suitable for domestic use.

CLAIMS

1. A membrane filtering device which allows selective component or components in a feed of solution to permeate through its membranes to give a permeate free of at least a substance in said feed by means of the semi-permeability of its membrane; said filter being formed by rolling a sheet structure into a scroll to form a cylindrical body, said sheet structure comprising at least two semi-permeable membranes and being rolled into said cylindrical body, with a clearance between said membranes, thus defining a first and a second space;

said first and second space being fully separated from each other by said membranes;

said membrane permitting the permeate of said feed solution to pass through while rejecting the impermeable substance therein;

any two spots in either one of the two spaces being fully intercommunicable with each other;

said first space having at least one opening respectively at a first and a second portion to communicate with the outside of said cylindrical body;

said second space having at least one opening to communicate with the outside of said cylindrical body;

said first space being partitioned by material impervious to the solution to be filtered, the partition being such as to define a lengthened single path in said first space for the solution to be filtered leading from said first portion to said second portion of said cylindrical body, said path travelling throughout the whole area of said membranes.

2. The membrane filtering device according to Claim 1, wherein said first space has a greater thickness in the radial direction of said cylindrical body than that of said second space.

3. The membrane filtering device according to Claim 1, wherein the central portion of said cylindrical body is a tube which serves as said second portion of said cylindrical body and around which said sheet is rolled.

4. The membrane filtering device according to Claim 1, wherein the partitioning means that defining a single path travelling throughout the whole area of said membranes is also provided in said second space.

5. The membrane filtering device according to Claim 1, wherein both ends of said cylindrical body are sealed To ensure that the two said spaces do not communicate with each other except through said membranes.

6. The membrane filter device according to Claim 1, wherein the second space opens into

a tube around which said sheet structure is rolled.

7. A membrane filtering device substantially as herein described with reference to the accompanying drawings.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1986, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.